## Amendments to the Drawings

The attached sheets of drawings replace original FIGS. 2, 4, 16a, 16b, 17-19, 26-29, 31-32, 34 and 36b.

Attachment: Replacement sheets.

## Remarks

Claims 1-6, 8-17, 19-48 and 53-71 are pending in this application, claims 1-6, 8-14, 41-48 and 53-65 are withdrawn from consideration, claims 17, 19-23, 29-40, 66 and 67 are rejected, and claims 24-28 are objected to. Applicants have canceled claims withdrawn from further consideration in the present application solely to place the application in condition for allowance.

Applicants request reconsideration of this application in view of the foregoing amendments and the following remarks.

### I. FIGS. 2, 4, 16a, 16b, 17-19, 26-29, 31-32, 34 and 36b

The Office action objects to FIGS. 2, 4, 16a, 16b, 17-19, 26-29, 31-32, 34 and 36b. Accompanying this Amendment are new drawings to replace these figures. No amendments have been made to, and no new matter has been added by, the replacement drawings. Applicants simply are filing replacement drawings as requested by the Office action. Accordingly, applicants request that the objection to the drawings be withdrawn.

### II. Claim Rejections Under 35 U.S.C. § 112, Second Paragraph

Applicants have amended claim 67 to delete references to "bottom" plate. Claim 67 now refers solely to "base" plate. Applicants therefore request that the rejection of claim 67 under 35 U.S.C. § 112, second paragraph, be withdrawn.

### III. General Comments Concerning Presently Claimed Technology and the Prior Art

#### A. Making Microfluidic Devices

The inventors of the technology disclosed and claimed in the present application are primarily concerned with bonding plural laminae together to form workpieces, or portions thereof, comprising microfluidic channels. Although workpieces other than microfluidic devices can be bonded together using the thermally assisted bonding unit, applicants have amended certain of the claims pending in this application to be directed specifically to processing microfluidic workpieces. The prior art cited against the application does not address issues associated with bonding laminae together that define microchannels using a thermally assisted bonding unit.

There typically are four aspects associated with a bonding process that must be considered: magnitude of the applied pressure; sensitivity; timing of the application of bonding pressure; and the uniformity of the applied pressure. For workpieces comprising microfluidic channels, a primary bonding problem is deflection of a lamina into an adjacent microchannel to occlude the channel either partially or completely, thereby either interfering with or preventing fluid flow in the channel. This is generally referred to as warpage. If the four pressure characteristics discussed above are not adequately considered during a bonding process to form a microfluidic workpiece, then fin warpage can occur to such an extent to be either deleterious to function or to preclude workpiece function entirely.

**B. McHerron**

Attached to this Amendment is a thesis by Christoph Pluess, one of the inventors named on the present application. The inventors were aware of the technology disclosed by McHerron's U.S. Patent No. 6,892,781, which is cited by the Patent Office to reject certain claims of the present application, when they began investigating technologies for bonding microfluidic laminae together to form workpieces. The McHerron technology is not suitable for bonding laminae together to form a microfluidic workpiece, as such technology does not adequately address all four aspects of a bonding process.

Portions of Mr. Pluess' thesis discuss the McHerron patent and the disclosed technology. For example, pages 16-17 (see the Appendix) of the thesis describe bonding pressure variations that occur by varying the gap size by $\pm 1 \mu m$. Such a small change in the gap size can produce a significant bonding pressure change, on the order of $\pm 1.6$ MPa. McHerron is silent as to adjusting the gap associated with the embodiment of FIG. 4, but does disclose that for other embodiments the gap size was adjusted manually with a feeler gauge. Achieving a desired gap size having an error of $\pm 1$ μm with a feeler gauge is virtually impossible.

Similarly, temperature fluctuations of $\pm 5°C$ produce a bonding pressure change of $\pm 4.7$ MPa. Heating expansion blocks to achieve a temperature fluctuation of $\pm 5°C$ also is problematic. These large pressure variations cannot be tolerated when producing microfluidic devices. That is, using the McHerron device, which was designed for bonding relatively large devices, to bond microfluidic devices, does not provide the degree of sensitivity, nor the

necessary timing associated with applying a bonding pressure, that is required for bonding microfluidic workpieces.

### C. Timing Application of Bonding Pressure

One consideration for bonding plural laminae together to form a microfluidic device involves timing the application of bonding pressure. This too is described in Christoph Pluess' Master's thesis, beginning on page 70 (Appendix), under the heading of "Effect of Pressure Timing on Fin Warpage." FIG. 5-9 of Mr. Pluess' Masters thesis establishes that there is a correlation between when the bonding pressure is applied in the heating cycle and the degree of warpage. By applying bonding pressure too early in the heating cycle, fin warpage is maximized. Conversely, applying bonding pressure at the end of the temperature ramp substantially decreases fin warpage. In fact, warpage is substantially non-existent if the bonding pressure is applied at the end of the temperature ramp. The prior art cited against the parent application does not address the issue of timing the application of bonding pressure and the temperature.

### D. Structure of Certain Embodiments of Applicants Device versus McHerron's

In terms of structure, the only figure of McHerron that teaches a device having a bellows is FIG. 4. FIG. 4 is discussed in McHerron at column 6, beginning at line 9. McHerron's bellows clearly is not a fixed volume expansion unit. FIG. 4 illustrates a workpiece 22 positioned in the bonding device. There is no gap between the workpiece and expansion block 14. In order for the workpiece to be inserted into McHerron's device, the volume must be decreased to provide a gap to insert the workpiece into the bonding device.

Applicants disclose the use of a load cell for certain embodiments of the thermal bonding unit. "Load cell," as used in the present application, refers to devices that are preloaded with a pressure for application to laminae and which have substantially fixed volumes. Because McHerron's bellows 36 must be of variable volume, McHerron does not disclose using a load cell, nor does McHerron disclose a device that includes a load cell in combination with a fluid expansion unit. This is a substantial structural distinction between the device of McHerron and applicants' device as recited in certain claims of the present application.

## IV. Rejection of Claims 17, 19, 23, 29, 35 and 38-40

Claims 17, 19, 23, 29, 35, and 38-40 are rejected as allegedly being anticipated under 35 U.S.C. § 102(b) by McHerron *et al.*, U.S. Patent No. 6,892,781 (McHerron). Applicants traverse this rejection and request that it be withdrawn.

Applicants have amended claim 17 to address the timing of applying a bonding pressure to the workpiece using the thermally assisted bonding unit as disclosed and claimed in the present application. These amendments further point out distinctions between applicants' claimed embodiment and the technology disclosed in the references cited against the present application. Specifically, applicants have amended claim 17 to recite that the method comprises "loading laminae in a thermally assisted bonding unit, placing the thermally assisted bonding unit and laminae in a furnace, heating the laminae and the bonding unit in the furnace to ± 50 °C of a bonding temperature, and applying a bonding pressure to the laminae using the thermally assisted bonding unit, where timing application of the bonding pressure is determined by adjusting fluid mass in the fluid expansion unit."

Support for amending certain claims of the present application, including independent claim 17, to refer to applying a bonding pressure within about ± 50 °C of a selected bonding temperature is provided in paragraph 172 of the application as published. Substantial disclosure is provided in the present application concerning applying a bonding pressure to plural laminae at a particular time in the heat ramp cycle in order to avoid fin warpage. Furthermore, such as with respect to FIG. 33, the application discloses adjusting the timing of applying bonding pressure by adjusting the fluid mass in the fluid expansion unit.

McHerron is silent as to the issue of adjusting the timing associated with applying a bonding pressure using a fluid expansion unit to apply pressure to plural laminae. In fact, based upon an electronic word search, McHerron never uses the word "timing." Furthermore, with respect to the disclosure associated with FIG. 4 at column 6, beginning at line 9, there is no disclosure by McHerron concerning adjusting fluid mass in the fluid expansion unit to time the application of a bonding pressure to plural laminae. For this reason, independent claim 17 is not anticipated by McHerron.

Claim 17 also is not obvious in view of McHerron. The present application is primarily directed to bonding plural laminae together to form a microfluidic device or a portion of a device comprising a microfluidic channel. Fin warpage is a substantial issue associated with such

workpieces. As substantiated by Mr. Pluess' thesis, the timing of applying bonding pressure to such laminae has a substantial impact on warpage. Because McHerron does not address microfluidics, and is entirely silent as to the issue of applying the bonding pressure at a particular heat ramp time to such devices, McHerron also does not render obvious the embodiment as recited in applicants' independent claim 17.

Claims 19, 23, and 29 depend from independent claim 17, and are allowable for the reasons stated above with respect to claim 17, and further in view of the patentable combination of features recited in these claims.

Independent claim 35 has been amended to recite that the method involves using a thermally assisted bonding device that comprises a frame, a platen assembly and a load cell. As discussed above, a "load cell" is a substantially constant volume device that stores bonding pressure, and then applies the stored bonding pressure to laminae at the desired time. For example, the load cell may comprise a mechanical or fluidic spring.

"Load cells" have a substantially constant volume. McHerron discloses bellows 36. Bellows 36 is not a constant volume load cell. For this reason, claim 35 is not anticipated by McHerron.

Claims 38-40 depend from claim 35, and are allowable for the reasons stated concerning independent claim 35 and further in view of the patentable combination of features recited in these claims. The rejection of claims 35 and 38-40 therefore also should be withdrawn.

## V. Rejection of Claims 17, 29-30 and 67

Claims 17, 29-30 and 67 are rejected as allegedly being anticipated under 35 U.S.C. § 102(b) by Barry Jr. *et al.*'s U.S. Patent No. 4,689,108 (Barry). Applicants traverse this rejection and request that it be withdrawn.

The technology disclosed and claimed in the present application is, for certain embodiments, directed to bonding laminae together at relatively high temperatures. As a result, the bonding unit with associated laminae are placed inside a heated furnace to achieve the bonding temperatures required to bond together plural laminae to form an integral workpiece or at least a portion thereof. Applicants have amended claim 17 to affirmatively recite placing the thermally assisted bonding unit and laminae in a furnace, and heating the laminae in the furnace.

This feature clearly is not taught by Barry, and hence the rejection of claim 17, and the claims that depend therefrom, must be withdrawn.

Claim 17 also is non-obvious in view of Barry. Barry does not contemplate using his device for high temperature bonding applications, and does not teach or suggest inserting the bonding unit into a furnace for high temperature bonding applications. Barry's device does include an integral heating component, i.e. sealing member 34. Barry states that member 34 can "support resistivity heated elements mounted in an aluminum block curved to fit against the workpiece." Barry, column 2, lines 36-37. However, such resistivity units would not be sufficient for high temperature bonding applications. And, the fact that the device includes integral heating components supports the conclusion that Barry does not suggest heating a workpiece associated with the Barry device in a furnace.

Furthermore, the Barry device includes many moveable parts that move relative to one another, such as turntables 15 and 32. Heating such moveable components at high temperature in a furnace would be problematic, as such parts likely would seize, and therefore, cease relative movement upon heating in the furnace. Based upon these structural considerations of the Barry device, it is clear that Barry did not contemplate using the device for high temperature applications, and does not teach or suggest inserting the device and associated components into a furnace to heat them to high bonding temperatures.

The Office action also asserts that Barry discloses a "pressure regulating spring" and that this apparently is the same as applicants' load cell. Applicants disagree. According to Barry, "[c]oil springs 30, 31 urge third plate 27 back toward second plate 10 (sic., 20) when hydraulic pressure is relieved." Barry, column 2, lines 20-21. These springs are not load cells, as they are not preloaded with pressure that allow timed application of bonding pressure to a workpiece.

Claims 29-30 and 67 depend from independent claim 17 and are allowable for the reasons stated for claim 17, and further in view of the patentable combinations of features recited in such claims. The rejection of claims 17, 29-30, and 67 under U.S.C. § 102(b) over Barry therefore should be withdrawn.

## VI. Rejection of Claims 20-22

Claims 20-22 are rejected as allegedly being obvious under 35 U.S.C. § 103(a) over McHerron and further in view of Ally *et al.*'s U.S. Patent No. 5,232,145 (Ally). Applicants traverse this rejection and request that it be withdrawn.

As discussed above, applicants have amended independent claim 17, from which claims 20-22 depend, to require timing of the bonding pressure applied by the thermally assisted bonding unit. McHerron does not teach these features.

Ally does not cure the deficiencies of McHerron relative to teaching or suggesting the features of independent claim 17, from which the rejected claims depend. Claims 20-22 add features associated with heating, such as convective heating, including using an inert gas. Ally is almost entirely directed to the concept of soldering in a reflow furnace, and therefore describes in detail the structure of the reflow furnace and the method for its operation.

Ally provides no disclosure concerning using a bonding unit as recited in independent claim17, from which rejected claims 20-22 depend. Hence Ally cannot provide any disclosure concerning using such a device to time the application of bonding pressure to form a workpiece. As a result, claims 20-22 are allowable in view of the combination of McHerron and Ally, and applicants request that the rejection of these claims be withdrawn.

## VII. Rejection of Claims 30-33 and 66

Claims 30-33 and 66 are rejected as allegedly being obvious under 35 U.S.C. § 103(a) over McHerron and further in view of Callahan *et al.*'s U.S. Patent Publication No. 2005/0007748 (Callahan). Applicants traverse this rejection and request that it be withdrawn.

Claims 30-33 and 66 also depend from independent claim 17 as amended and discussed above. Callahan clearly provides no discussion of a thermally assisted bonding unit comprising at least one fluid expansion unit. Callahan therefore cannot cure the deficiencies of McHerron relative to teaching timing the application of bonding pressure by adjusting the fluid mass in a fluid expansion unit such that the unit applies bonding pressure at a desired time subsequent to initiating a heating cycle. Claims 30-33 and 66 therefore are not obvious in view of the combination of McHerron and Callahan for the reasons stated above for claim 17, and further in view of the patentable combination of features recited in these claims.

## VIII. Rejection of Claim 34

Claim 34 is rejected as allegedly being obvious under 35 U.S.C. § 103(a) over McHerron *et al.* Applicants traverse this rejection and request that it be withdrawn.

The deficiencies of McHerron relative to independent claim 17, from which claim 34 depends, are discussed above. As a result, claim 34 is allowable under 35 U.S.C. § 103(a) over McHerron.

## IX. Rejection of Claims 36-37

Claims 36-37 are rejected under 35 U.S.C. § 103(a) as allegedly being obvious over McHerron in view of Ally. Applicants traverse this rejection and request that it be withdrawn.

Claims 36 and 37 depend from independent claim 35. Neither McHerron nor Ally teaches a thermally-assisted loading unit comprising a load cell, nor the method for using such a device as recited in claim 35 as amended. The combination therefore cannot teach or suggest the features of claim 35. As a result, claims 36-37 are allowable for the reasons stated for independent claim 35, and further in view of the patentable combination of features recited in these claims.

## X. Objected-To Claims

Claims 24-28 and 68-71 are objected to as being dependent upon a rejected base claim. Claim 24 depended from claim 17. Applicants have rewritten claim 24 in independent format to include the limitations of both claims 23 and 17. As a result, claim 24 as amended is currently in condition for allowance, as are claims 25-28, which depend from claim 24.

Claims 68-71 also are objected to. Applicants have amended claim 68 to substantially include the features of claim 67 from which it depends. As rewritten, claim 68 includes both a fluidic expansion unit and a load cell. The primary reference cited against the claims of the present application, i.e. McHerron, includes a fluidic expansion unit, but it does not include a fluidic expansion unit in combination with a load cell. For this reason, claim 68 as rewritten in independent format is in condition for allowance, and such action is requested.

## XI. New Claims

Applicants also have added new claims 72-75 to more fully claim the subject matter disclosed in the present application. Independent claim 72 recites providing a thermally assisted bonding unit that comprises a load cell. As discussed above, McHerron, the primary reference cited against the present application, does not disclose a thermally assisted bonding unit that comprises a load cell. And, despite assertions to the contrary in the Office action, Barry also does not disclose a load cell. Moreover, claim 72 requires placing the bonding unit and associated laminae in a furnace, heating the laminae and the bonding unit in the furnace to ± 50 °C of a bonding temperature, and applying a bonding pressure to the laminae subsequent to initiating a heating cycle. These features also are not disclosed by the references cited against the present application.

Claims 73-75 depend from claim 72, and are allowable for the reasons stated above with respect to claim 72.

## XII. Conclusion

The present application is in condition for allowance. Applicants request that the Patent Office issue a Notice of Allowance.

Respectfully submitted,

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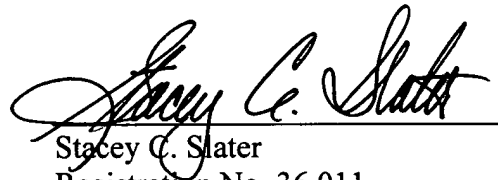
By 

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